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AMERICAN METEOROLOGICAL JOURNAL.

A Monthly Review of Meteorology, Medical Climatology and Geography.

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VOL. IV. ANN ARBOR, JUNE, 1887. No. 2.

CURRENT NOTES.

RUSSIAN THUNDER-STORMS.—Through some unaccountable error, this article in the May number of this journal was attributed to Mr. Alexander McAdie. We owe the article, not to Mr. McAdie, but to Mr. Geo. E. Curtis. We sincerely regret the error. H.

VARIATIONS OF THE MEAN SEA-LEVEL.—It is customary to think that the level of the sea, since the water is free to flow, must be uniform, but theoretical considerations and actual measurements prove otherwise. Apropos of improvements in maps, Mr. Ravenstein gave to the Royal Geographical Society, sometime ago, an abstract of some results which are of great interest. It seems that carefully conducted and repeated spirit-levelings show that the Mediterranean is, as might have been expected from its greater salinity, and density, at a lower level than the North Atlantic. Thus, at Trieste the level is 1.94 feet below that at Amsterdam, at Marseilles, 2.69 feet lower. At Brest it is 5.315 feet higher than at Marseilles, though Brest is much nearer than Amsterdam. Even in the same sea, decided differences of level may exist; for instance, the Baltic is 1.64 feet higher at Memel than on the coast of Holstein. And about the British Islands the sea does not stand at a uniform level. The extreme difference, found so far, is between Rispond, in Sutherlandshire, the northwestern county of Scotland, and Kilbaha, at the mouth of the Shannon, on the west coast of Ireland. At

Rispond the mean level is 1.736 above that at Liverpool; at Kilbaha, it is 1,442 feet below, making a total difference of 3.178 feet.

INTERNATIONAL FORM OF PUBLICATION.—The International Meteorological Committee is much interested in reducing the publication of observations and resumés to one form and, at the last meeting of the committee at Paris, Dr. Neumager made the following remarks on the subject, which will be of especial interest to American readers:

"While the international form of publication has been rapidly introduced throughout the whole of Europe, it is to be regretted that it has not been adopted for any station in America, excepting Greenland and Santiago (Chili). Neither the Canadian system, that of the Signal Service, that of the Argentine Republic, nor the observatories at Havana and Rio de Cordoba, communicate their observations with that entireness and uniformity which are necessary for discussions.

"Notwithstanding their relatively considerable size, the above-mentioned publications only contain resumés of different kinds, such as the mean daily temperature, etc. The Signal Service publications are only Daily Weather Reports and Charts, with the exception of the supplements given in the Annual Reports. It is true that the former show the elements of the same observation, but not the successive observations of one station. Researches in which certain stations are taken as a basis, are rendered extremely difficult.

"Meteorology would be greatly benefitted by the publication of observations from 20 to 30 stations in Canada and the United States, including especially Pike's Peak and Mount Washington, together with the lower comparative stations. The same may be said with regard to some meteorological stations in Central and South America. The use of the international forms for these observations must possess in all cases the greatest advantages for meteorology and climatology, especially as the stations or systems specified represent conditions which differ in essential points from those of Europe.

"I think it superfluous to urge this proposal more fully upon the International Committee, because every one engaged upon meterological and synoptic work knows the importance of it. I am also of the opinion that the expression of the desire of the Committee would suffice for obtaining a change in the publications in question which would put them in harmony with the international publications."

All the members of the commiltee agreed to make these representations to the heads of the services in America.

Areas of High Pressure.—Professor Loomis' twenty-second contribution to meteorology, published in the *American Journal of Science*, is supplementary to other papers on the same subject and relates more especially to areas of high pressure of very great extent. It is found that these areas, when of unusually high pressure, sometimes stretch from the Pacific to the Atlantic over North America, or over a large part of Europasia. He gives a list of 81 cases in which the pressure surpassed 31 inches. Of these 74 occurred in Europasia, 6 over North America, 1 over the North Atlantic, and none over the Pacific; 63, or 79 per cent., occurred in December and January, and none from April to September, inclusive. With but one exception, their latitude was always between 50° and 60°.

The largest areas are in Europasia; the barometer there rises to a height unknown in other parts of the world, reaching at Barnaul 31.63 and at Ssemipalatinsk 31.72 inches. The center of these areas, though it vibrates to and fro, seems to have no decided progressive motion. These areas also continue for a long time, remaining eight or ten days above 31 inches, and even for fifty days far above the mean pressure. A pressure of 30.50 inches is almost uninterrupted over some part of Europasia during the winter months.

Professor Loomis finds these areas to be the necessary concomitants of the areas of low pressure, their chief supply of air being from the low areas which prevail over the Atlantic ocean. Their low temperature is in part cause, in part effect. Their long duration is due to the unusually favorable conditions

prevailing over this large continental area. As to the motions of these areas, the author says:

"Areas of low pressure seem to be endowed with a power of locomotion which resides within themselves. The heat liberated in the condensation of vapor develops a power which draws in the surrounding air, and this motion, combined with the movement which results from the general system of atmospheric circulation, causes a rapid displacement of the low center. Areas of high pressure exhibit no such power. Their low temperature creates a tendency to crowd toward a warmer region; and this tendency is obscurely seen in the high areas of Europe and Asia. It is more distinctly seen in the high areas of the United States, probably on account of the proximity of a much higher temperature, viz: the Gulf of Mexico on the south, and the Atlantic Ocean with the Gulf Stream on the east. Aside from this cause, the movement of areas of high pressure seems to depend entirely upon external forces. A neighboring area of low pressure may draw off the air from one side, and thereby cause a displacement of the center of maximum pressure; or the high area may be reënforced at the top in such a manner as to cause a rapid movement of the center of maximum pressure, in a direction and with a velocity which are apparently subject to no law."

VELOCITY OF PHYSICAL RAYS.—Uriah A. Boyden, Esq., of Boston, Mass., has deposited with the Franklin Institute the sum of one thousand dollars, to be awarded as a premium to "any resident of North America who shall determine by experiment whether all rays of light and other physical rays, are or are not transmitted with the same velocity."

The following conditions have been established for the award of this premium:

1. Any resident of North America or the West India Islands, may be a competitor for the premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the secretary of the

Franklin Institute a memoir, describing in detail the apparatus, mode of experimenting, and the results; and all memoirs received by him before the first day of January, one thousand eight hundred and eighty-eight, will, as soon as possible after this date, be transmitted to the committee of judges.

3. The board of managers of the Franklin Institute shall, before the first day of January, one thousand eight hundred and eighty-eight, select three citizens of the United States of competent scientific ability, to whom the memoir shall be referred; and the said judges shall examine the memoirs and report to the Franklin Institute whether, in their opinion, and if so, which of their memoirs is worthy of the premium. And on their report the Franklin Institute shall decide whether the premium shall be awarded as recommended by the judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with some motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the secretary of the Franklin Institute to keep these envelopes securely and unopened until the judges shall have finished their examination; when, should the judges be of the opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the author communicated to the Institute.

5. Should the judges think proper they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the premium shall become the property of the Franklin Institute, and shall be published as it may direct.

THE SCOTTISH MARINE STATION AT GRANTON.—Considerable activity is displayed by the directors of the Scottish Marine Station at Granton, Edinburgh. Investigations of the salinity and temperature of the waters of the deep lakes and estuaries, have been carried on, steadily for the past three years. The

condition of the Firth of Forth as to salinity and temperature has been satisfactorily determined, and several papers of great value contributed to the *Roy. Soc. Edin. Proc.* All this work is done without government aid. The difficulties met with, in this respect are aptly shown in the following extract from the *Edinburgh Scotsman*, May 21, 1897: "Scottish geographers look with envy to the United States, where maps are made with regard to configuration as well as topography. While our Ordnance maps leave little to complain of, and the same is true of the admiralty charts, concerned only with navigable waters, the deep lakes of Scotland form a great gulf between the domains of the Ordnance Survey and the Hydrographic Office. They furnish nice open spaces on the six-inch map, which rest the eye bewildered by the thronging contour lines of the hillsides and the mis-spelt Gaelic names of the peaks; they give scope to the imagination in a sphere whence imagination might easily be entirely banished; and when in the course of study any one wishes to find out anything about their depth, he must simply make a survey for himself.

Enterprises of national, or international, perhaps of cosmical importance are at present being supported in Scotland without government aid. As a piece of abstract ethics this is wrong, for such an institution as Ben Nevis Observatory ought to be entirely upheld by the state; but there are, fortunately, some who have sufficient public spirit to occupy the paradoxical position of doing what is wrong because it is right. The survey of the deep lakes is just such another thing; and rather than wait for it to be done in the proper way, by the proper authorities, one or two directors of the Scottish Marine Station have done the work on some lochs themselves, less thoroughly in one way than if a regular surveying party had been employed, but more completely in another." A. M.

HOURLY READINGS OF WIND VELOCITY AND ATMOSPHERIC PRESSURE IN THE UNITED STATES.—It was stated in the May JOURNAL that the forthcoming hourly wind velocities about to appear in the "Blue Hill Observations for 1886," were probably

the only complete data of the kind which had been published for the United States. While this is not strictly true, either in regard to the wind or the pressure, the published hourly data are very meagre, as the following list, prepared by Prof. Abbe and embracing the published observations covering a year, or any considerable portion of a year, shows:

Philadelphia, Pa. Girard College. Hourly eye observations of pressure, temperature, wind and precipitation from 1840 to 1845. A. D. Bache.—*Girard College Observations.*

Albany, N. Y. Dudley Observatory. Pressure and wind for each hour (with breaks in the first years) from 1865 to 1870. G. W. Hough.—*Annals of the Dudley Observatory.*

Mount Washington, N. H., and Pike's Peak, Colo. Hourly pressures and temperatures for two months.—*Chief Signal Officer's Report, 1882.*

Chicago and the Lake Crib, Ill. Hourly wind velocities for two months. H. A. Hazen.—*Signal Service Notes, No. VI.*

Point Barrow, Alaska. Hourly eye observations of pressure and wind for nearly two years. P. H. Ray.—*International Polar Expedition, 1881.*

Coast Survey Reports. Fragmentary sets of hourly pressure observations.

From this list it will be seen that more published hourly readings for this country are very desirable. A number of automatic records exist which have not been reduced for publication or are still in manuscript. Among the former are those from the self-recording instruments of the Chief Signal Office, in Washington, those of Dr. Draper in New York and at the City Engineer's Office in Providence, R. I., and among the latter class are those which Prof. Abbe has for Cincinnati. A. L. R.

Tropical Wyoming.—One of the most interesting and, at the same time, one of the most difficult branches of meteorology is that of geological climates. The Great Basin of the Western United States—between the Rocky Mountains and the Sierra Nevada,—proves, by the studies conducted by members of the U. S. Geological Survey, and by independent students, to have

had a very interesting history in this regard, which, in its general features and for later geological times, can be sketched with considerable certainty.

Professor O. C. Marsh, in his recent monograph of an order of extinct gigantic mammals, which has been published by the Survey, gives us a clear picture of the climate and conditions of one part of the great basin, in the early part of the tertiary or geological age immediately preceding our own. The region in question is the upper valley of Green River, lying mostly in Wyoming. It is a valley perhaps 200 miles long by 75 broad, surrounded then, as now, by a rim of mountains. The Union Pacific Railroad passes through it lengthwise, and to a traveller of the present time it appears picturesque but by no means attractive. Its principal vegetation now is sage-brush; even grass is very scarce. Continued erosion by water and wind has cut it up into buttes and terraces, columns and towers of curious and fantastic forms. The sparseness of vegetation enables the observer to see the bright and varied colors of the exposed rocks and clays, and this gives an oddness to the view which can scarcely be paralleled elsewhere. It is a desolate and uninviting country to which, if to any region, the name of "bad lands" peculiarly applies.

It seems, according to Professor Marsh, that in the middle of the eocene times this valley contained a great lake, at least a hundred miles long. In the waters of this lake was abundance of fishes, while on its borders grew, in great luxuriance, palms and other tropical plants. Serpents, lizards crocodiles, and turtles were very common, and everywhere was found a great variety of mammals, not one of which is represented in living species to-day, and many were of enormous size. There were ancient beasts of prey, one about as large as the lion. There were ancestral forms of the horse and the tapir, also of the hog. There were also representatives of the lemurs and kangaroos, now known only in distant parts of the earth, but, curiously enough, no monkeys have been found. With some of the forms common then, the type has completely died out, leaving no living representatives.

The largest known animals of the valley were the *Dinocerata*, the objects of Professor Marsh's monograph. They were something like the hippopotamus and rhinoceros, but present curious analogies to the groups to which the horse, pig, and elephant belong. Some of them were enormous animals; the largest species being about twelve feet long, six and a half feet high, and five feet across the hips. These were long, heavy, unwieldy animals, weighing perhaps three tons or more. They were provided with two pairs of prominent horns, one pair on the top of the head and the other at about the middle of the nose, and had besides a pair of tusks. These animals were very abundant for a long time and probably lived in herds. Their favorite resort seems to have been the borders of the lake, and their food was evidently the soft, succulent vegetation which, then as now, grows in such places.

This makes a very different picture of southern Wyoming from that which one sees now. Now the sage-brush represents the vegetation and the rattlesnake and the jack-rabbit the fauna. The change from the one state to the other can be explained only in part. The valley was gradually filled in by materials brought down from the surrounding mountains. Meantime this entire region was slowly elevated, and eventually the lake broke through the mountain rim, on the south side, and was drained off. With these changes, which are proved by the geology and topography of the valley and the region around it, came a fall of temperature and failure in rain which is not sufficiently explained. For these changes must be given a lapse of time which was undoubtedly enormous, but the duration of which there are no means of measuring. Geologically it was not long ago, but it would probably take six or more figures to express in years the period that has elapsed since Wyoming had a tropical climate.

THE GREAT LAKES.—In a valuable article in the *Am. Journal of Science* Mr. L. Y. Schermerhorn has recently summed up some of the leading features of our knowledge of the Great

Lakes, according to our information. The water surface and drainage-basin are given in the following table:

	Area of water surface, square miles.	Area of water shed, square miles.	Aggregate area of basin, square miles.
Lake Superior	31,200	51,600	82,800
St. Mary's River	150	800	950
Lake Michigan	22,450	37,700	60,150
Lake Huron and Georgian Bay	23,800	31,700	55,500
St. Clair River	25	3,800	3,825
Lake St. Clair	410	3.400	3,810
Detroit River	25	1 200	1,225
Lake Erie	9,960	22,700	32,660
Niagara River	15	300	315
Lake Ontario	7,240	21,600	28,840
	95,275	174,800	270,075

Further facts may be tabulated as follows:

	Height above sea level in feet.	Greatest depth.	Mean depth.	Mean annual precipitation.	Average discharge in cub ft. per sec.	Difference between high and low water of the year.
Lake Superior	601.8	1008	475	29 inches.	86,000	1.2 feet.
Lake Michigan	581.3	870	325	32 "	225,000	1.3 "
Lake Huron	581.3	702	250	30 "		1.3 "
Lake Erie	572.9	210	70—	34 "	265,000	1.6 "
Lake Ontario	246.6	738	300	34 "	300.000	1.9 "

The length of the shore line of the lakes and the connecting rivers is about 5,400 miles. The volume of water in the lakes is about 6,000 cubic miles, of which Lake Superior contains nearly half.

"The principal changes in the elevation of the lake surfaces are those due to the wind and to rainfall. Prof. Whittlesey states that on Aug. 18, 1848, a gale from the N. E. reduced the water level at Buffalo, N. Y., to a point 15½ feet lower than the surface of the lake on Oct. 18, 1849, at which time a terrible gale occured from the S. W. This was an excessive difference of level and one of rare occurrence.

"During protracted autumn gales waves have been observed which through reliable means measured from 15 to 18 feet above the normal surface.

"The second class of variations, those due to rainfall, occur with considerable regularity. The lowest water in the year generally occurs in Lakes Ontario, Erie, Michigan and Huron in the months of November and March, and on Superior in March. The highest water occurs on the first named lakes in June and

July, while on Superior it is delayed until September." The average difference derived from twenty years' observation, between the high and low water of the year, is given in the preceding table.

"The highest observed stage of the lakes occurred in the summer of 1838, and the lowest in the summer of 1847: the difference between the two stages being about 4½ feet.

"Observations made by the U. S. Survey have established the existence of small tides, which at Chicago had an amplitude of 1½ inches for the neap tide and about 3 inches for the spring tides.

"There is still another class of oscillations called *seiches*, which have been already observed in the Swiss Lakes and for which a solution in all respects satisfactory has not been offered. Whenever the lakes are sufficiently free from the disturbing action of wind to permit observations, a quite regular series of small waves or pulsations can be detected, which have an interval of about ten minutes from impulse to impulse. These pulsations seem to occur almost without cessation on Lake Superior. Besides having tides in common with the ocean, the lakes have well-defined land and lake breezes; the breeze from the lakes landward commencing in summer at 8 or 10 o'clock A. M., and continuing until sunset, and the breeze from the land lakeward from 9 or 10 P. M. until sunrise.

"The modifying effect of these large bodies of water upon land areas contiguous to the lakes is noticeable. At Milwaukee, Wis., which is directly upon the shore of Lake Michigan, the mean annual temperature is as follows: winter, 24° F., spring, 41° F., summer, 67° F., autumn, 49° F., annual range, 110° F. At points in the same latitude, but from 50 to 100 miles inland, the mean winter and autumn temperatures are about 2° F., lower, and mean spring and summer temperatures nearly 5° F., higher, while the annual range is about 5° F., greater."

LAND AND SEA-BREEZES.—One has sometimes cause to regret that the poetical view of nature is lost or at least neglected by those who search after the causes of things. Our accounts of the

winds are now so largely statistical, and so much taken up with the relations of velocity, isobars and gradients, that it is worth while to recall the other view, and quote an account of the land and sea-breezes from Captain William Dampier's "Discourse of Trade-winds, Breezes Storms," etc., given in his "Voyages and Descriptions" (London, 1705).

"Sea-breezes do commonly rise in the morning about nine a clock, sometimes sooner, sometimes later; they first approach the shore, so gently, as if they were afraid to come near it, and ofttimes they make some faint breathings, and as if not willing to offend, they make a halt, and seem ready to retire. I have waited many a time both ashore to receive the pleasure, and at sea to take the benefit of it. It comes in a fine small black curle upon the water, when as all the sea between it and the shore not yet reached by it, is as smooth and even as glass in comparison; in half an hour's time after it has reached the shore it fans pretty briskly, and so increaseth gradually till 12 a clock, then it is commonly strongest, and lasts so till 2 or 3 a very brisk gale; about 12 at noon it also veers off to sea two or three points, or more in very fair weather. After 3 a clock it begins to dye away again, and gradually withdraws its force till all is spent, and about 5 a clock, sooner or later, according as the weather is, it is lull'd asleep, and comes no more till the next morning.

"These winds are as constantly expected as the day in their proper latitudes, and seldom fail but in the wet season. On all the coasts of the Main, whether in the East or West Indies, or Guinea, they rise in the morning and withdraw towards evening, yet capes and headlands have the greatest benefit of them, where they are highest, rise earlier and blow later. Bays contrarily have the disadvantage, for there they blow but faintly at best, and their continuance is but short.

* * * * * *

"Land-breezes are as remarkable as any winds that I have yet treated of; they are quite contrary to the sea-breezes; for those blow right from the shore, but the sea-breeze right in upon the shore; and as the sea-breezes do blow in the day and rest in

the night; so on the contrary, these do blow in the night and rest in the day, and so they do alternately succeed each other. For when the sea-breezes have performed their offices of the day by breathing on their respective coasts, they in the evening do either withdraw from the coast, or lye down to rest; then the land-winds whose office is to breath in the night, moved by the same order of divine impulse, do rouze out of their private recesses and gently fan the air till the next morning; and then their task ends and they leave the stage."

* * * * [On the coast of Coroccos] in the night or morning, while the land-wind blows, we find fresh gales out of the bays, but when we come abreast of the head-lands, we find it calm; yet see the breeze curling on the water on both sides of us, and sometimes get a spurt of it to help us forward: and having recovered the wind out of the next bay, we pass by the mouth of it presently, till we come to the next head; and there we lye becalmed as before. * * * The land-winds on the coast of Peru and Mexico in the South Seas, are in most places right off from the shore, else the fishermen could never go out to sea, as they do, on bark-loggs. And as the land-winds are true there, so are the sea-breezes also; for with the land-wind they go out to fish, and return in again with the sea-winds. * * *

"These land-winds are very cold, and though the sea-breezes are always much stronger, yet these are colder by far. The sea-breezes indeed are very comfortable and refreshing; for the hottest time in all the day is about 9, 10 or 11 a clock in the morning, in the interval between both breezes, for then it is commonly calm, and then people pant for breath, especially if it is late before the sea-breez comes, but afterwards the breez allays the heat. However, in the evening again after the sea-breez is spent, it is very hot till the land-wind springs up, which is sometimes not till 12 a clock or after."

There is much more, equally entertaining: we might apply here the opinion that was expressed by one Captain Conant in a letter written in 1698 about another of Captain Dampier's books. He said, "I have gone through it, and find it very well worth my time, being very delightsome, and I believe true."

W. M. D.

OBSERVATIONS OF CLOUDS.—The International Meteorological Committee, the report of whose meeting in Paris, in 1885, has been only recently published, recommend, through a committee, the observations of clouds on the following scheme. The committee consisted of Messrs. Brito Capello, Hildebrandsson and Ley, and their report follows:

It is sufficient for the observations actually in question to divide the clouds into two groups:

A.—Upper Clouds or Cirri-form Clouds; and

B.—Lower Clouds.

Whenever an observer is in doubt in which of the two catagories he should place a cloud, it will be better to consider it as a lower cloud.*

For these observations the annexed formula has been drawn up:

1. *Time of Observation.*—The first column contains the date; the second column the nearest hour to the time of observation. It is desirable that these observations should be made three times a day, when it is possible. To fix certain hours is not possible, but it is desirable that the observer should study the sky as often as his time permits him, and that he shall take notes of all important phenomena, above all of all those that relate to the cirrus. The morning observations, local time, and those at midday (Greenwich time) are the most important for the synoptic charts.

2. *Movements of the Upper Clouds.*—The direction from which they come must be noticed. This often appears difficult on account of their ordinarily slow movement, but if the observer remains perfectly stationary for some seconds, he will easily observe their motion relatively to a steeple, a flag-staff, a ridge of a building, or something of the same kind. Above all the clouds which are nearest to the zenith should be noted as much as possible. It would be useful to erect a pole upon an open place, and so to station oneself that a distinct point of the cloud may appear to move from the summit of the pole

* The white clouds in the forms of balls of cotton, called "cirro-cumulus" or "alto-cumulus," are ranged among *lower clouds.*

in a direct line towards the observer, or in the opposite direction. If the observations are made at a window, it is convenient to stretch across the window some horizontal or vertical threads, crossing each other at right angles, or better still, to trace marking lines upon the window-panes. In order to avoid mistakes, it is necessary, especially if the movement of the clouds is very slow, to rest the head for support against the wall or upon the hand, if the arm has a firm support. When there are no clouds near the zenith, the observations are more difficult, because perspective is apt to cause some errors. For the avoidance of these errors different experience is necessary, that is to say,the observer should compare the movement of one part of a cloud near the zenith with those other parts in the same stratum of clouds, situated at elevations above the horizon, and in different directions. It is safest to observe a part which moves straight towards the observer, or in an opposite direction. It is, however, desirable that some simple nephoscopes should be provided, so that greater exactitude may be attained. M. Marié Davy's instrument, used at the Observatory of Mountsouris, and that of M. C. Fornioni, are especially simple and suitable.

3. *Velocity of the Upper Clouds.*—These clouds are rarely quite motionless, but owing to their great distance, they ordinarily seem to move very slowly, and generally, but not always, less rapidly than the lower clouds. Their velocity, estimated by sight, is indicated by the following numbers:

0 = Absence of motion;
1 = Very slight motion;
2 = Ordinary motion;
3 = Rapid motion;
4 = Extremely rapid motion.

We here encounter the same difficulties as in determining the direction of these clouds. Their apparent velocity depends not only upon their height above the horizon, but also on their direction with reference to the observer. In general the velocity should not be determined, except when the cloud is near the zenith; it needs much practice to be able to determine with any exactitude the velocity of clouds near the horizon. We may

erect a pole for the determination of the direction of clouds, which can also be employed to estimate their velocity with much accuracy. For this object a mark must be made, for example a colored ring, at the elevation of the eye, and at 1.7 m. (5 feet $7\frac{1}{4}$ inches), above this a horizontal cross must be placed indicating the cardinal points. Next there must be attached to this cross a ring of metal wire of 0·9 m. (3 feet) in diameter, so that the pole passes through the center. If the eye be placed at the lower mark, the ring will be about 15° from the zenith. In observing the time occupied by the passage of a certain part of a cloud from the summit of the pole to the ring, we have a velocity of 1, if the time is more than ten minutes; 2, if the time is between 5 and 10 minutes; 3, if the time is below 5 minutes; and 4, if the time is less than 1 minute. In the employment of a nephoscope of the mirror type, we can trace around its center a circle, of which the radius corresponds to a motion of 15°, or else we may trace two concentric circles in such a way that the image of a cloud near the zenith shall take the same time in passsing from one to the other of these circles, as the cloud itself takes in traversing 15° from the zenith.

4. *Point of radiation.*—Cirrus is often visible under the form of thin parallel bands appearing to issue, on account of perspective, from a point on the horizon; sometimes traverse all the sky, and these bands have two points of radiation, situated 180° one from the other. These forms of cloud, which play an important part in the popular forecasts of the weather in nearly every country, are sometimes called "polar bands," sometimes "Noah's arks," sometimes "roots of the winds," etc. At the meeting of the Committee at Copenhagen, in accordance with the proposal of M. Mascart, the simple denomination of "*Radiation of cirrus*" has been adopted. The points of radiation are also easy to discover, when the clouds do not reach as far as the horizon. The simplest manner is to turn as if we wished to pass under the highest part of such a band, or of its prolongation. The points of radiation are then at the right and left hand, or at 90° from the point of the horizon towards which we have turned. Of the two points of opposite radiation, we note down that which

is the nearest to the quarter from whence the clouds move. If the clouds come *e. g.*, from the W., and the bands are lying in the direction S.W.—N. E., it is S.W. which is the point of radiation. If the motion of the clouds be imperceptible, or if they move at a right angle to the direction in which the bands stretch, which rarely happens, both points of the horizon in question should be noted down.

5. *Density and position of the cirrus bank.*—The upper clouds often take the form of a canopy, or veil, of more or less density, which, lying above the horizon, is similar to a thin bank, and is light or grayish. It is in this veil that halos and coronæ of the sun and moon frequently appear, parhelia, and paraselenæ. As this form of cloud is intimately related to barometric depressions, it is important to notice it.

(a) *The density.*—0=very thin and ill-defined; 1=thin, but definitely formed; 2=rather heavy; 3=heavy; 4=very heavy and of a deep color.

(b.) *Position*, or direction in which the veil, or bank, appears the thickest.

6. *Motion and velocity of the lower clouds.*—As the lowest clouds often appear simultaneously with the upper clouds, their movement and velocity must be equally noticed, particularly on such occasions. We can determine them in the same way as the cirrus, but these observations are easier, the clouds being much nearer the observer than the upper clouds. Their apparent velocity being on the average much greater than that of cirrus is estimated at 0=no motion, 1=slow, 2=moderately quick, 3=quick, 4=very quick; that is to say according to the scale for a long time in use for the observation of storms in France, Scandinavia, and other countries also.

VII. The direction and velocity of the wind are determined in the same way as usual.

VIII. The observers are requested never to enter an observation which is not certain.

The observations here proposed are, as we have already said, but very simple ones, which can be easily carried out in every civilized country, and almost by anyone, provided a little pains

is taken with them. We know also by experience that it is not difficult to find persons disposed to undertake such work and capable of executing it in a satisfactory manner. Take, for instance, the series of observations, embracing a great number of consecutive years, which have been carried on in many countries, notably in England and Sweden. More detailed observations will some day be carried on, with still more important results. Much, however, has already been gained, if at a great number of stations situated in every country of the world, we can make numerous observations upon the direction of the wind, at three different heights above the surface of the earth.

Even at sea we ought to make regular observations of this kind, which would evidently be of very great utility. Hitherto we have, with reason, regarded the observations made upon the movements of the clouds on board ship as very difficult. Such observations also are very rare. However, it ought not to be difficult to conduct them with the help of suitable nephoscopes. The meteorologists who took part in the expedition round the world of the Swedish frigate "Vanadis" in 1883–'85 were provided with a nephoscope (on the model of M. Fornioni) suspended like a compass. It is desirable that such experiments should be made in the navies of all countries. When it is difficult or impossible to ascertain the movement or velocity of the cirrus at sea, the radiation can in many cases be easily observed, and this, even by itself, it is important to register.

In England experiments have been made during the last few years of introducing cirrus observations into telegraphic meteorology. It appears that such a system would be of great importance to the forecasts of weather. We invite the directors of all the Central Meteorological Offices to follow the example set by England. It does not seem possible at present to give definite instructions. We must at first follow the method adopted in England; we shall be able, in case of need, to modify it later according to practical exigencies.

With regard to *detailed observations upon cirrus*, and a new cloud classification, it appears to us that definite instructions ought not as yet to be given. It is first necessary for this

purpose that special research should be made. We can but invite all who are interested in these observations to work with us at the solution of these interesting problems, which will doubtless be of the utmost importance to the whole science of meteorology. It will be of especial importance for a new cloud classification to have good representations by photography, or lithography, of the forms most prevalent in each country. For our part, we shall not only pursue these researches, but we shall pay attention to all that is done by other meteorologists, and as soon as results have been obtained which appear likely to lead to the introduction of new observations in each country, or at least at the principal stations, we shall not be slow to insist upon a similar plan.

Publication of the proposed observations.—Lastly, with respect to the publication of the observations here proposed, we should wish to publish them *in extenso* in every country, at the end of the Annual Reports published by the Institutes or Central Offices. The number of the observations taken at each station differ considerably in different countries, as much on account of the varying zeal of the observers, as of the differences in the general meteorological conditions of each country. At Upsala, the progress or radiation of cirrus has been capable of being observed on 125 days during the year 1883.

(Signed) J. C. DE BRITO CAPELLO.
H. HILDEBRAND HILDEBRANDSSON.
August 17th, 1885. W. CLEMENT LEY.

RECOMMENDATION.

For this reason we would propose to establish at each Meteorological Observatory of the First Order a system of *three* stations, all in telephonic connection with each other, one of which should be at a considerable distance from the other two, say three miles [5,000 metres]. By this means we should obtain a suitable base for cirrus observations. The two other stations should be placed at a distance of 500 or 1,000 yards [metres] apart, to serve as a base for the observation of the lower clouds.

TORNADO PREDICTIONS AND THEIR VERIFICATION.

A method adopted in predicting local destructive storms was described in the JOURNAL, Vol. I, No. 3, (July, 1884), of which the following is a general outline:

The portion of the United States east of the Rocky Mountains is divided into eighteen districts, as represented on the map (Vol. I, p. 85). The 9 A. M. weather maps are examined daily, with special reference to the conditions favorable for the development of destructive storms, and a list of the districts believed to be favorably situated for their occurrence is prepared.

In a book of manuscript maps are charted the locations of all storms, whether popularly termed tornadoes, hurricanes, or whirlwinds, that are reported as destructive to life or property. Reports of such storms are furnished by a large number of special voluntary reporters distributed throughout the tornado districts.

Storm reports are collected also from newspapers and other sources, and it seems probable that through all these means an approximately complete list of such storms is obtained. These storms, charted on daily maps, furnish, therefore, a basis for verifying the predictions; in this verification, each one of the districts enumerated may be considered as a separate prediction that destructive storms will occur within that area.

The following table, I, contains for June, 1885, a daily summary, 1st, of the districts for which tornadoes were predicted, and, 2d, of those in which destructive storms were reported.

(*a*) Let us first ascertain the success of the predictions without regard to the individual districts, *i. e.*, considering them simply as predictions that one or more destructive storms will occur somewhere in the United States. Table I shows that there were predictions on 16 days, storms on 17 days, coincidences of storms and predictions on 14 days, whence we have: 14 predictions verified, 2 predictions not verified, 3 storms not predicted.

TABLE I.

Date.	Predictions.					Occurrences.					
June 2	9	15				13	15				
" 3	13	15				9	13	14	15		
" 4	9					8	9				
" 5	2	4				16					
" 6	12	15	16	17	18						
" 7	8	9	12	13		3	8	13	18	15	17
" 8	4	5	6	7	12	8					
" 9	11	12									
" 12	13	14	15	16		15	16	18			
" 13	15	16				13					
" 14	9	13	15			8	9	13	15	16	17
" 15	15	17				9	13	15			
" 16						14					
" 17						14	9				
" 19						14	16				
" 20	13	16				13	14	16			
" 21	2	8				3	8	11	13	14	
" 22	1					2	12				
" 27	16					15	18				
Total	40					46					

[NOTE.—The numbers designate the districts.]

As the lack of knowledge seems to be the same, both in kind and degree, for the storms unpredicted as for the predictions unverified, when only the simple question of occurrence enters into the prediction, the total failure may be considered to be the sum of these two elements. In the present example, there are five failures and fourteen cases of success; therefore the percentage of success will be 14÷19, or 74 per cent.

To obtain a measure of the skill in prediction, the portion of the total success that is due to probable accidental coincidences must be eliminated, for only by so doing can the success of predictions of different phenomena be rendered comparable, and the figures for each have any mutual significance. This is necessary also in order to make a proper test of the relative success of predictions based on different theories of the occurrence of the phenomena—as, for example, the lunar, planetary and sunspot theories that are frequently put forth as the basis of successful weather prediction.

The probable number of chance coincidences may be computed by the formula*

$$e = \frac{op}{s} \text{ in which}$$

e = number of chance coincidences.
o = " " occurrences.
p = " " predictions.
s = total number of possible cases.

*See Signal Service Notes, No. XIII, 1885, p. 14.

In the present instance, $o = 17$, $p = 16$, $s = 30$, whence $e = 9$. Professor Gilbert has assumed (this journal, I, 1884, 166–172) that the residual percentage of success due only to skill in prediction may be found by subtracting e from the numerator and denominator of the original fraction giving the ratio of verification. Applying this method to the ratio of verification given above, $14 \div 19$, we have 50 per cent. as the residual percentage of success due to skill. Thus, while 74 per cent. represents the total success of the predictions—without regard to locality—about two-thirds of this success is due to skill and one-third of it is attainable by chance, *i. e.*, by one who should make at hap hazard an equal number of predictions.

(*b*) To obtain the percentage of verification of the predictions as made for each district, the same methods are applicable. From table I, we have $o = 46$, $p = 40$, c (predictions verified) $= 15$; whence the percentage of verification is 21 per cent. To obtain e when the predictions are made for more than one district, the formula, $e = \frac{op}{s}$, requires an extension due to the fact that the occurrences are not distributed uniformly over the several districts, but have a relative frequency now fairly well determined, and also obtained in each case from the figures themselves. The relative frequency being known, the predictions might be given the same distribution by a sunspot prediction or mere guess. The value of e, therefore, must be computed for each district separately, and the formula becomes

$$e = \frac{o_1 p_1}{s} + \frac{o_2 p_2}{s} + \frac{o_3 p_3}{s} + \cdots \frac{o_n p_n}{s} = \Sigma_n \frac{op}{s}$$

Obtaining e by means of this formula and proceeding as before, the residual percentage of success due to skill is found to be 14 per cent.

What is the meaning of these small percentages of verification? Are the predictions poor, or is the method of verification erroneous and misleading? Neither one. The method of verification, when rightly interpreted, has brought us a valuable and instructive result. The significance of the figures is

not that the predictions are poor, but that too much has been attempted. The prediction of tornadoes for fixed districts is an uneconomical and an inappropriate method and, for the present state of our knowledge, the districts have been made too small.

If the districts were twice as large as those at present, or, what is nearly the same, if we consider as a verification an occurrence in a district directly adjoining one for which a storm was predicted, the conditions will not be too easy for even the most ambitious meteorologist.

Arranging contiguous districts as in table II, and considering two districts joined by a hyphen to represent one prediction or one occurrence, we obtain the following result: 32 occurrences, 33 predictions, and 19 coincidences. These figures give 40 per cent. for the measure of total success; so that as the result of doubling the size of the districts, we have doubled the percentage of verification. Neglecting the storms not predicted, 56 per cent. of the actual predictions were justified by storms in the district predicted or in an adjacent one. The percentage compares favorably with the verifications of cautionary signals, of which latter, in May, 1885, only 54 per cent. were justified by winds within the hundred mile limit.

TABLE II.

Date	Predictions.	Occurrences.	Coincidences.
June 2	13-9 15	13 15	2
" 3	13 15	13-14 9-15	2
" 4	9	8-9	1
" 5	2 4	16	0
" 6	15-16 17-18 12		0
" 7	8 9 12 13	3-8 13-15 17-18	2
" 8	4-5 6 7 12	8	1
" 9	11-12		0
" 12	13-14 15-16	15-16 18	1
" 13	15 16	13	1
" 14	9 13 15	8-9 13 15-16 17	3
" 15	15 17	9 13-15	1
" 16		14	0
" 17		14 9	0
" 19		14-16	0
" 20	13 16	13 14-16	2
" 21	2 8	3-8 11-13 14	1
" 22	1-2	2 12	1
" 27	15-16	15 18	1
	34	32	19

19 predictions (56 per cent.) verified.
15 " (44 per cent. not verified.
13 storms (41 per cent.) not predicted.

$$\text{Percentage of total success} = \frac{19}{19 + 28} = .40$$

The results that we have obtained, therefore, show clearly that the number of the districts for which prediction was attempted is out of proportion to our knowledge of tornadoes, and to the accuracy with which the occurrence can be foretold.

Not only are the districts too small, but the whole system of fixed districts is inappropriate for making advantageous predictions. The preceding methods for their precise verification spring naturally and logically from the system of districting employed, and have no reference to the principles underlying the predictions. The results, therefore, are applicable whatever may be the theory of tornado action or the basis of their prediction. It consequently happens that, although the percentage of verification gives a rigid measure of success, and will indicate accurately an increase or decrease in skill, yet, in individual instances, there results an apparent injustice to the predictor, due to the fact that the fixed districts do not lie in such position with respect to the anticipated tornado area as to admit of making an advantageous prediction. For example, the area considered favorable for tornadoes may overlie the edges of three separate districts, each of which must be included in the prediction. Tornadoes will very likely occur in one of the three districts and not in the other two; in this case the numerical percentage of verification, computed by the preceding method, will be so small as to produce an erroneous impression as to the real success of the work.

In view of these considerations, it seems desirable that the terms of prediction, and the corresponding method of verification, should be more nearly allied to the principles adopted in making the predictions.

The most important discovery thus far made as to the locality of tornadoes is that they occur on the southeast quadrant of areas of low pressure, at an average distance from the center now fairly well determined. This generalization, together with some additional knowledge of the actual temperature, pressure, winds and humidity, forms the essential basis of tornado prediction.

Since, in the present state of our knowledge, the anticipated

area favorable for tornadoes is, in general, a single undivided district, it follows that the prediction should likewise be made for a single district covering all the territory within which tornadoes are expected to occur. Such a district, movable from day to day, must take the place of rigid, fixed districts, having no relation to each individual case.

The shape and size to be adopted for this movable district are dependent on the actual distribution of tornadoes.

(*a*) *Shape.* The data already accumulated indicates that, in general, the area liable to tornado occurrence on any day is represented very nearly by a rectangle whose length is one and a half times its breadth, or by an ellipse whose major and minor axes have this ratio.

(*b*) *Size.* As to the necessary size of the area, observations show that, on the same day, tornadoes may frequently occur over a section of country 400 by 600 miles in extent; consequently a prediction for a district of less size will fail at times to include all of the occurrences. The actual size to be adopted however, is a practical question dependent on the relative loss in alarming many people where the warning will not be verified, and in failing to forewarn some whose property will be devastated. Of two different sized areas of prediction, the larger will include the greater number of occurrences, but it will probably be of less total utility than the smaller area if the ratio of people benefited to the number alarmed is smaller.

If an experimental rectangle, 400 by 600 miles in extent, or an ellipse or other figure of equivalent area, be first assumed for the area of prediction, a practical criterion by which to improve its size seems to be found in the following rule. A change to a smaller size should be made, if the relative difference in the percentages of verification for the two areas is smaller than the relative difference in the areas themselves.

(*c*) *Method of prediction and verification.* On each day, a card representing the assumed area of prediction will be placed on the weather map in such position as best to cover the locality where tornadoes are anticipated; the outline of the district thus covered will be traced by a line drawn around the perimeter of

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the card. After all reports of tornadoes have been received and charted, the relative number of tornadoes occurring within and without the marked area will form a basis for computing the percentage of verification. This method, is better adapted to the peculiarities of tornado prediction and verification than those hitherto employed.

The use of a single movable district corresponds to what we know of the occurrence of tornadoes, and to the principles that obtain in their prediction. The method is sufficiently rigid to furnish a definite measure of the skill in prediction, while, in its numerical results, it will present a fairer idea of the success of the work than is given by the use of complex formulæ applied to irrelevant districts.

It is believed that the percentage of verification obtained by predicting in the way above described will be sufficiently high to warrant the public announcement of tornado predictions with the other predictions of the Signal Service. The terms to be used in such announcements is a subject of additional consideration, not touched upon in the above suggestions.

G. E. CURTIS.

THE DISTRIBUTION OF THE WEATHER IN STORMS AND ANTI-CYCLONES AS AFFECTED BY LOCAL INFLUENCES.

INTRODUCTION.

The effect of local influences on the weather has received some attention in America, but its systematic study has as yet scarcely begun. It is a direction in which our State Weather Services can do such excellent work that a statement of the results gathered during a cursory study will it is hoped be an incentive to further study. In fact, the subject can only be studied in a general way except with the data gathered by a close net-work of stations such as those of our State Weather Services.* The writer's investigations on the subject have been mostly confined to the United States, though the general principles found here probably apply as well elsewhere.

*Our Signal Service deserves praise for its efforts to multiply these State Weather Services.

DEFINITION.

Under the word *weather* is here included all of the meteorolgical elements, viz., pressure, temperature, cloudiness, etc.; and each will be considered in turn. By *local influences* are meant those produced by irregularities in the contour of the earth's surface, in the composition of the surface, and in the distribution of land and water.

PRESSURE.

The most important characteristic which distinguishes storms and anti-cyclones is differences in the static pressure of the atmosphere. It is well known that the pressure at adjacent places is quite different if the two are at different heights. This is usually allowed for by reducing the observed pressure at both to sea-level. Dr. Hann has recently shown,* however, that in the vicinity of the Sonnblick the range of pressure is noticeably greater in the valleys than on the highlands, on account of the greater range of temperature in the valleys. Hence the reduced pressure observed on the highlands can not be compared with the observed readings in the valley unless it is corrected to the valley station, and then it could not be compared with observations on the plains. The difference, however, does not seem to be large. Again, recent observations would seem to indicate that when the air is in motion there arises a dynamic pressure of the air against objects which more or less affects the static pressure. During a gale in 1886 the wind pressure gauge at Blue Hill Observatory recorded a horizontal pressure of the air of 44 pounds to the square foot. Prof. Ferrel has calculated that the compression of the air blowing against a horizontal surface at the rate of 68 miles per hour would cause an increased height of the barometer of .18 inch.† It would seem then that air blowing against the slope of a hill or mountain would become compressed and cause the barometer to read higher than at adjacent level stations. Other facts would seem to indicate that on the opposite side of the hill the pressure would be re-

* Met. Zeitschrift, Vol. II, p. 45.

†Chief Sig. Officer's Report, Part II, p. 333. This JOURNAL, Vol. III, p. 562.

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duced. The only observation I know on this point was that made by Prof. G. K. Gilbert, who found in one case a difference of .15 of an inch between barometer readings on opposite sides of the apex of a mountain peak.*

The pressure, as a rule, falls lower in the vicinity of large bodies of water than at a distance from them. There are several reasons for this, viz., decreased friction, increased vapor, etc. In the United States the lowest readings of the barometer in storms are found in the Lake Region and along the Atlantic coast.

TEMPERATURE.

The distribution of the temperature in storms and anti-cyclones is markedly influenced by irregularities of the earth's surface. Prof. Harrington's articles on the Chinook Winds, which have just been concluded in this JOURNAL, show how greatly the air becomes heated when the circulation of a storm or anti-cyclone causes the air to pass over the Rocky Mountain range. Prof. Davis has recently found some good cases of the same effect in the mountains of northern New England. Cases no doubt occur all along the range of the Alleghanys, and wherever the wind blows across mountains of any considerable size. But, perhaps the most marked general effect on the temperature arising from local influences occurs during the quiet, clear nights which accompany anti-cyclones. During such nights the earth's surface loses heat by radiation much more rapidly than the air, and as a consequence the air near the earth's surface, either by contact with the surface or by conduction, becomes much cooler than the air above it. The records of Blue Hill Observatory show a number of cases where the air was found from 10° to 20° warmer at the top than on the slope of the hill a few hundred feet below the summit. Examples of the same kind are found in the articles of J. W. Chickering, Jr., and S. Alexander in Vol. I, pp. 213 and 467 of this JOURNAL. At places where the contour of the earth's surface is quite uneven, differences of temperature at closely adjacent places some-

* Science, Vol. VII, p. 571.

times become very marked. In such places the coldest air slides down the slopes, accumulates in the lowest places, and makes the temperature of the valleys much lower than on the adjacent hill sides. In one case at Ann Arbor, Mich., the writer found the temperature 15° lower in a valley than on top of a hill a quarter of a mile distant, and at one place down a steep slope he found a difference of 3° within a distance of twenty-five feet. Last winter Mr. Welton, of Waterbury, Conn., found a difference of 25° between the air in a valley and on a hill side only half a mile away.

These facts partially explain the cause of the large differences of temperature frequently observed by different persons in the same town, as well as the large differences sometimes reported from adjacent towns. Cincinnati is situated in a valley, and it has been stated that the temperature observed on clear nights at the Signal Service station in that city is lower than that of surrounding stations of the Ohio Weather Bureau. The temperature observations at other Signal Service stations are probably affected in a similar manner.

Large bodies of water are conservators of heat, and affect the distribution in storms and anticyclones in a number of ways which are pretty generally known and will not be mentioned here. The New England Meteorological Society has begun investigating the sea breeze, and hopes to make our knowledge more definite on this point.

Woeikoff and Assmann have shown * that large areas of snow affect the distribution of temperature by causing a persistent low temperature where they are situated, and a variable temperature in their vicinity.

Sandy soils heat and cool rapidly, and are supposed to influence the temperature of the air above them. In Tennessee the writer has found considerable difference in the temperature of the air observed on sandy plateaus and on adjacent fertile plains; but how much was to be attributed to the difference in the composition of the soil he is unable to say.

Popular Science Monthly, April, 1887, and this JOURNAL, Vol. III, p. 389.

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WIND.

Observations show that the wind is also greatly influenced by the irregularities of the earth's surface, and wind observations taken in large valleys are almost of no use in determining the cyclonic circulation in a storm, since the wind almost always tends to blow either up or down the valley. Thus at Knoxville, Tenn., the prevailing winds are continuously from the southwest or northeast*; and it is not uncommon, when there is a storm central in the eastern United States, to find the wind at Knoxville blowing from the northeast, when at surrounding stations it is blowing from the west. In a similar manner the winds at Denver, Col., blow almost continuously from either north or south; and other stations of the Signal Service are undoubtedly affected in a similar manner.

Near large bodies of water the wind tends to blow more at right angles to the center of a storm, and with greater velocity than at interior stations.

The wind velocity observed is also largely determined by the observer's position on the contour of the earth's surface. In a broken country the wind velocities observed near the general level of the land are smaller than on plains. Again, observations clearly show that the wind's velocity rapidly increases with height above the general level of the earth's surface. If an anemometer is situated on an eminence, or elevated artificially to a considerable height, it will record higher wind velocities than anemometers at a lower level. The average wind velocities obtained at Blue Hill Observatory is over 50 per cent. higher than that obtained at the Boston Signal Service station which is about 500 feet lower and ten miles distant. The anemometers at the different Signal Service stations vary considerably in height, and the records can only be compared in a rough and general way.

Not only is the wind velocity measured on elevations of the earth's surface greater than at lower stations because of the increase of wind velocity with height, but because the elevation

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Chief Signal Officer's Report, 1885.

becomes an obstruction to the free air movement, and the air rushes more rapidly over it, just as water flows more rapidly across the top of the dam than in the open stream. From the top of Blue Hill the shadows of detached lower clouds can be seen on the plains for a distance of several miles, and the velocity of the clouds can be determined by timing the movements of the shadows through known distances. Such measurements have been made when practicable during the last six months; and the average of about thirty measurements obtained at different times during the six months give a slightly less velocity for the clouds than the average of the wind velocities recorded at the same time by the instruments on Blue Hill. It is not probable that the velocity of the clouds vary greatly from that of the air in which they float, so it seems evident that the velocity of the wind recorded on Blue Hill is greater than that of the open air at the same height. The same is no doubt true for Mount Washington and other mountains. By means of a cloud mirror which I have devised for the purpose, the angular velocity of clouds can be measured; then, when their actual velocities are known from the movements of their shadows, their heights can be determined. During the winter the lower clouds whose heights were thus determined were mostly between 3,000 and 5,000 feet above sea level, and their velocity was much less than that of the wind on Mount Washington, as well as could be determined from the observations reported from Mount Washington at 7 A. M. and 11 P. M. Recently the clouds have been higher; and the measurements made about noon on four different dates gave heights near 6,000 feet, or higher. The average velocity of these clouds was only 22 miles per hour, while the average velocity of the wind on Mount Washington at 7 A. M. of the same dates was 46 miles per hour, which apparently indicates that the wind velocity observed on Mount Washington is higher than the wind velocity in the open air at the same height. There is a slight diurnal variation in the wind velocity on Mount Washington, but it is not sufficient to account for the large difference found above.

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HUMIDITY, CLOUDINESS AND RAIN.

Slight irregularities in the contour of the earth's surface, except on the sea coast, probably do not affect the distribution of the cloudiness and rain; though they noticeably affect the distribution of humidity, it usually being found damper in valleys and near the earth's surface than at slight elevations. But elevations of one or two thousand feet have a very apparent effect, and where the slope is gradual their influence extends over a wide area. The slope apparently increases the ascending component of the air in storms on the side against which the wind blows, and decreases it on the opposite side. In the one case the ascent of the air, and the cooling from expansion, is more rapid than it would be in the absence of the elevation. There is consequently an increased cloudiness and rain; while on the opposite side the ascending component is lessened, and there is decreased cloudiness and rain. The Rocky Mountains, on account of their great height, act very decidedly in this manner, as is shown by the enormous rainfall on their western slope in in the winter season; and by the clear, warm, dry air of the "chinook wind," which after passing across and down the eastern slope of the mountains enters a storm in the interior of the United States.

The same effect is produced, though in a less marked degree, by the Alleghany Mountains. The influence of these mountains is not noticeable on the average rainfall; but the reason, I think, is because the east winds from the Atlantic Ocean are damper and give a greater precipitation, thus counterbalancing the effect on the opposite side of the mountain of the more frequent though drier west wind. In individual storms, however, the effect of the Alleghanies on the distribution of cloudiness and rain is very apparent. It is only necessary to casually glance at the U. S. weather maps, especially during winter storms after they are central off the Atlantic coast, to see how much more frequently it is raining or cloudy at Pittsburg and stations in western New York than it is at stations on the east side of the mountains nearer the center of lowest pressure. Prof. Upton's researches indicate that in storms passing New England, the

greatest precipitation takes place in central New England,* which at once suggests that the phenomenon is due to the mountains in that region. At Boston the sky almost invariably shows signs of clearing immediately after the center of an area of low pressure has passed to the east and the winds have changed to west or northwest. This, I think, is in part due to the fact that the air has passed over the mountains in central New England, and its ascending component is now lessened or destroyed by its motion down an incline. The same seems to be true all along the eastern slope of the Alleghanies. Prof. Loomis found that, "at Philadelphia the amount of rain which falls while the barometer is descending is nearly three times as great as that which falls while the barometer is rising, and during the six colder months of the year the rainfall in the former case is nealy five times as great as in the latter."† This great excess of rainfall with a falling barometer, near the Atlantic coast, is, however, largely due to the fact that the winds accompanying the falling barometer come directly off the ocean, which is the source from whence the winds draw their moisture; and hence only a slight ascent is sufficient to cause cloudiness and precipitation. It makes no difference what is the height of the barometer, if the gradient is moderately steep and directed so as to give easterly winds, it will rain along the Atlantic coast, sometimes almost in the center of an anti-cyclone. The Great Lakes also act as effective agents in supplying the air with moisture, and thus influencing the distribution of cloud and rain in storms. Whenever the gradient is directed so as to give westerly winds, especially if the pressure is low, it will almost invariably be found cloudy or raining along the eastern coast of these lakes at such stations as Oswego, Buffalo, Cleveland, Marquette, etc. The Chief Signal Officer's Reports show that the winds which bring clearing weather at these stations are northeasterly winds, which apparently indicate that clearing weather does not occur until they are well within the area of an anti-cyclone.

In the vicinity of Dakota and Montana the distance from the

*This JOURNAL, Vol. III, p. 416.
†Loomis' 12th paper.

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large bodies of water on the east is very great, and the Chief Signal Officer's Reports show that the winds in this region which are most frequently followed by rain are those from some westerly or northerly quarter. This apparently indicates that the greatest rainfall in this region occurs in the rear of storms, as was found by Loomis to be the case in parts of central Europe. I was recently, for practice, predicting from the U. S. weather maps the weather to be expected during the succeeding 24 hours for different portions of the United States. I found that if I predicted preciptation in front of storms in the "Extreme Northwest," especially in winter, the prediction almost invariably failed, since precipitation seemed to occur almost entirely in the rear of the storms. The supply of moisture in this region appears to come from British America, and is perhaps ultimately derived from the Pacific Ocean.

CONCLUSION.

The temperature, wind, etc., observed at many of the Signal Service stations, are undoubtedly affected by local influences extending over very small areas, and since it is the general conditions of the weather which is wanted for predicting the movements of storms, etc., it would seem very desirable that the effects of these local conditions should be eliminated, or at least allowed for. It is admittedly a difficult undertaking to entirely eliminate the effect of local influences; but at present the Signal Service is gathering a vast mass of heterogeneous data which not only vitiates their predictions, but must necessarily more or less vitiate generalizations based on these data.

H. HELM CLAYTON.

BLUE HILL METEOROLOGICAL OBSERVATORY, May 14, 1887.

REDUCTION OF AIR PRESSURE TO SEA LEVEL.

The importance of this question, especially for the region of the United States west of the Mississippi river, will be readily recognized. While the problem admits of an easy practical solution in the case of a high mountain station, if there is an-

other station at its base near sea-level, yet it becomes very intricate, in some parts of the world, where there are high level planes, extending thousands of miles, 3,000 and 4,000 feet above sea-level. Within a few years, many high level stations have been established west of the Mississippi; notably three in British America, Edmonton, Medicine Hat and Q'Appelle, which will aid in solving the problem.

Use of a high level plane to which to make reductions. In order to obviate some of the difficulties met with, especially in the case of a large number of stations lying in an extended region at some height above sea, it has been proposed to use a sub-plane of reduction passing near a majority of the stations to which to reduce down and up all the readings at these stations. It will be readily seen that this plan introduces sources of error much more serious than those sought to be obviated. If the pressure changed independently of the temperature, this proposition might be tried, though even in such case it is evident a sea-level plane would do just as well. When we consider that the pressure changes with the temperature, that it is permanently 4° to 5° higher at the south end than at the north end of a plane extending 15° of latitude, that it varies from season to season six or even seven times as much at the north as at the south, that it would be impossible to connect reductions to such a plane with those near sea-level at its edge, the plan appears very inadvisable. As a matter of fact the use of such a plane would tend to give a low pressure when in reality it is high, and vice versa, *i. e.*, whenever the temperature was below the mean for the month the air would be contracted by the cold below the plane and while there was actually high pressure in the whole region yet the plane would show a depression. The use of such a plane would be similar to the use of constants for reducing to sea-level computed on a certain monthly mean temperature. The best plan for showing the inadvisability of using such a plane is to suppose it to pass through the summit of Mt. Washington, or any high station, and to determine the "departure" from the mean, both at the summit and the base, during different temperature conditions. I have selected the month of

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December, 1879, for showing this, as it has already been fully computed; see Professional Paper Signal Service No. VI, page 9. The following table contains the more important results of the one already published.

"DEPARTURES" OF AIR PRESSURE, DURING DIFFERENT TEMPERATURE CONDITIONS, AT MT. WASHINGTON, BURLINGTON AND PORTLAND. MONTH OF DECEMBER, 1879.

Day.	Temp. above or below Mean.	Pressure above or below the mean at			Mean B. & P.	(4)—(6)
		Bur.	Mt. W.	Port.		
7	+26°	—.66″	—.23″	—.75″	—.70″	+.47″
11	+25	—.45	—.07	—.46	—.46	+.39
13	—10	+.44	+.22	+.42	+.43	—.21
15	+12	—.61	—.27	—.56	—.58	+.31
18	—22	+.22	—.17	+.13	+.18	—.35
19	— 9	+.25	+.06	+.18	+.22	—.16
21	—34	+.48	—.21	+.25	+.36	—.57
22	—16	+.11	+.05	+.38	+.24	—.19
26	—27	—.06	—.43	—.14	—.10	—.33
27	—22	+.07	—.19	+.04	+.06	—.25
29	+12	—.37	—.12	—.23	—.30	+.18
(1)	(2)	(3)	(4)	(5)	(6)	(7)

It will probably be admitted by every one, that the level of the air, if such an expression may be allowed, is precisely the same, or ordinarily will have such inclination that the mean of the results at Burlington and Portland will give the exact conditions at the point over Mt. Washington. The above table shows conclusively, as already premised, that when the temperature is high there is an increase of pressure at Mt. Washington and the reverse is true when the temperature is low. For example, with the temperature of the air-column 26° above the mean, on the 7th, the summit of Mt. Washington showed an increase of air pressure of .47″ and with the temperature 34° below the mean on the 21st there was a depression of .57″. Or what amounts to the same thing, if Burlington and Portland had been carried up to the plane passing through the summit of Mt. Washington on the 21st, their mean would have been .57″ higher than the actual air pressure at the summit.

Interdependence of pressure and temperature on a high plateau. It may be argued that, in the centre of a wide plane at high level, the usual law between pressure and temperature does not hold, but that they are somewhat independent. It is evi-

dent, however, that if a cold wave extends over the whole region, as it often does, then at the edge of the high region the air will be contracted as usual, and we may assume that, the same result would have ensued at each station, if there had been no plateau. A test for a satisfactory reduction then would be a good connection between low and high neighboring stations. One thing is certain, we must adopt some general law for reduction and if occasionally the temperature has too much weight, it can be told by inspection and in drawing isobars, it will be necessary to modify them slightly at stations where an abnormal temperature prevails.

TEMPERATURE TO BE USED.

This question may be divided into two distinct heads: 1st. How shall we obtain the mean temperature of the air column extending from a high station to sea-level, and 2nd, how shall we eliminate the effect of diurnal range in temperature? While it is a simple matter to obtain the mean temperature at base and summit of an isolated peak which will give an approximate mean for the air column, this method cannot be applied to an extended high level plane. In the latter case we have the following rules: 1st. In the centre of such a plane, the temperature will not differ much from that of sea-level; if the plateau were not there, if anything the temperature, especially in winter, would be too high; for example, the winter temperature at Cheyenne is 1 to 2 degrees higher than at North Platte nearly 3,300 feet lower down. 2nd. We may draw first isotherms connecting together sea-level stations on either side, being careful to bend them in accordance with known laws of temperature distribution, and from these obtain the difference for the air column, and apply it to the temperature as a constant.

The following table gives such a list of constants, obtained from observations up to the present time.

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AMOUNT TO BE ADDED TO THE OBSERVED TEMPERATURE AT SEVERAL HIGH STATIONS IN ORDER TO REDUCE IT TO SEA LEVEL.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Bridger.	8°	12°	12°	11°	10°	11°	14°	14°	13°	11°	12°	9°
Cheyenne.....	−2	−1	3	7	7	7	7	7	7	6	1	0
Deadwood.....	−4	−2	0	4	6	6	7	6	5	3	0	0
Denver.....	−2	−1	0	2	2	2	3	2	2	2	0	0
Eagle Rock...	8	10	10	5	4	5	3	2	3	7	10	8
Mt. Wash.....	16	17	19	22	22	22	22	21	20	19	20	18
Pike's Peak...	24	27	32	36	37	37	35	35	34	33	27	24
Ploche.....	8	10	11	7	10	10	9	8	9	9	7	8
Prescott.....	10	10	10	9	11	12	10	10	12	11	8	10
Santa Fe.....	7	7	10	10	11	11	12	12	12	10	7	9
Winnemucca.	7	10	8	5	7	7	5	5	9	10	9	10
Bidwell.....	9	11	10	8	8	8	7	7	10	11	12	12
Maginnis.....	0	0	1	2	3	5	6	6	4	2	0	0
Montrose.....	4	4	4	4	4	4	4	4	4	4	4	4
Poplar River.	6	6	5	3	1	0	0	0	1	3	5	6
Stanton.....	1	1	5	4	7	10	14	13	10	9	2	3

The following remarks are made:

1st. An examination of this table will very quickly show, how utterly impossible it is to make any uniform reduction of a number of feet to the degree, as was attempted by Mr. Upton several years ago. The reduction of Cheyenne to North Platte, at the rate of 1,000 feet to one degree, would be about plus 3° winter and summer, while the table shows that it should be — 2° in winter and + 7° in summer. At Stanton it would be six degrees to sea-level while we see that it should be 2° in winter and 13° in summer, or the rule 1,000 feet to one degree would make an error of + 4° in winter and — 7° in summer.

2d. There are at many stations local causes seriously affecting the temperature and causing it to differ from that of the neighborhood, *e. g.*, the station may be in a ravine where there is a free air circulation or the exposure of the thermometer may be largely affected by local causes. These sources of error have, however, been nearly eliminated.

3d. In the winter season there are practically three strips of temperature running north and south, (*a*) Pacific coast region and plateaux to eastward, warm, (*b*) British Columbia and Missouri valley, cold, (*c*) Mississippi valley and eastward with temperature between (*a*) and (*b*). Now it is evident that at times the temperature conditions in (*a*) lap over into (*b*) and *vice versa*, so that we cannot obtain a fair reduction at many high

stations, but by inspection we can learn whether stations on the borders of (*a*) and (*b*) have a temperature above or below the average and give them less weight accordingly in drawing isobars and isotherms.

4th. At some of the higher stations on the above border, at times, we may have temperatures of either (*a*) or (*b*) while the lower stations have the reverse.

DIURNAL RANGE OF TEMPERATURE.

This is the second head suggested above. Investigation has shown that at a high station the full effect of changes in temperature is not felt immediately by the air column extending from base to summit, but there is a slight lagging. In the case of Mt. Washington, experiments have shown that the mean temperature of the previous 24 hours is about the value affecting the air column at any moment. In getting this temperature we may either take the mean of any equi-distant observations for the 24 hours, in making the reduction at a certain hour, or if we have not these we may apply a certain correction to reduce the temperature observed to an approximate mean for 24 hours. In the U. S. we have observations at seven hours, fifteen hours, and twenty-three hours, and it is only necessary to take the mean of three successive observations including the one we wish to reduce. It may be urged that there is an apparent connection between the high temperature in the afternoon and the low pressure prevailing at the same time. A little experience will show, however, that the diurnal range of pressure at high stations in the western plateaux is not affected by the changes in temperature; for a notable example, see Lt. Wheeler's Geological Survey Report, 1877, Part II, p. 527.

REDUCTION OF PRESSURE TO SEA-LEVEL.

After the previous discussion regarding the intricacy of the problem relating to temperature, it may naturally be said that a satisfactory combination of temperature and pressure to give a correct sea-level pressure is well nigh impossible. At the outset we may remark, that, if we find a relation between the temperature and pressure at any station which will give a reduction comparable with the observed value at a lower station, whether

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the high station be upon an isolated peak or on a gently inclined plane, we may regard the reduction as fairly satisfactory. If, in addition, we can apply the same relation to a large number of stations at various heights over an extended region, we may assume it for making reductions, though there may be a few stations more or less isolated which will need a slight modification of the general law. A comparison of observations for about six years at the base and summit of Mt. Washington has given a very satisfactory table of reduction. For the extended plateau region of the west it is not so easy to obtain a good reduction, but an approximate table has already been published, see Professional Paper Signal Service, No. VI, and this has been used in constructing the tables for this paper.

USE OF A CORRECTION DEPENDENT ON THE OBSERVED PRESSURE.

The full theoretical formula demands a slight change in the reduction varying with the observed pressure. For example at a height of 6,200 feet the reduction would vary about .027 inches for each change in pressure of .1 inch above or below the mean. It was shown by the present writer in the *American Journal of Science* for May, 1881, p. 366, that at stations in the west there is a very slight variation of the reduction dependent on the observed pressure, but it is just opposite to that as determined from the theoretical formula. Prof. Loomis from an independent investigation announced the same fact in the same journal for July, 1881. A careful computation from six years observations at Mt. Washington has shown this effect to be inappreciable. (See P. P. No. VI, p. 8) and that we may use a table with a simple temperature argument for making reductions. Computations have been made with mean values at Mt. Washington and at several European mountain stations and have shown that without exception this correction for pressure introduces an error, and that by far the best reduction is to be had by using a single pressure for computing from the formula. A probable reason for this disagreement with theory may be as follows: We are obliged to assume that the mean temperature of the air column is equal to the mean of observed values at base and summit, but it is well known that this is not the case,

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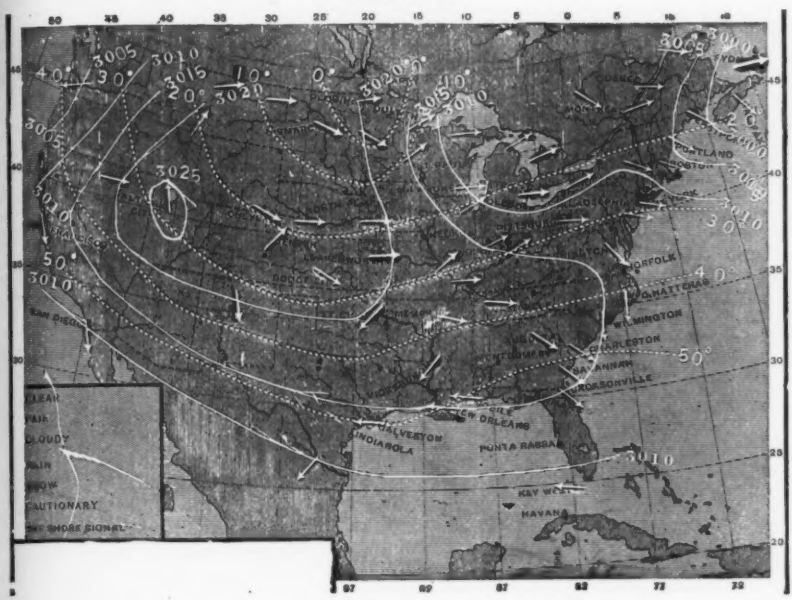
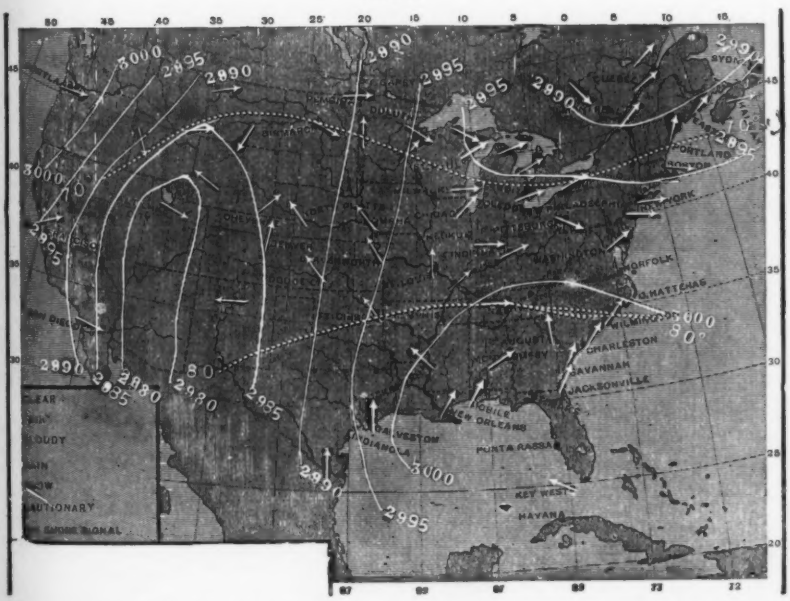
FIFTEEN YEARS' NORMAL PRESSURE, TEMPERATURE, AND WIND DIRECTION (LAMBERT'S FORMULA).

JANUARY.



JULY.



These plates belong with the article on "Reduction of Air Pressure to Sea Level" published in the June number.

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e. g., Ruhlmann has shown that at Great Saint Bernard the mean of base and summit gives 2—3 degrees too low a temperature in winter and the reverse in summer. May it not be that in the very dry regions of the west this effect is so marked as to actually give a diminished reduction with a higher pressure? The error introduced at Mt. Washington by the pressure correction sometimes amounts to .1 inch in the reduction for a monthly mean pressure. For daily observations the errors introduced at times become very large. The following table gives reduction at Mt. Washington both by the table in this paper and by applying a correction for pressure.

REDUCTION OF PRESSURE AT MT. WASHINGTON TO SEA-LEVEL EACH DAY AT THE TWENTY-THREE HOUR OBSERVATION DURING SEPTEMBER, 1885.

Day.	Temperature.	Pressure.	Pressure Correction.	Reduced to sea-level using (4)	Reduced by table.	Pressure observed at sea-level.	Errors.	
							(5)—(7)	(6)—(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	37	23.58	.0	29.73	29.79	29.80	—.07	—.01
2	29	.81	.05	30.13	30.13	30.13	.0	.0
3	35	.84	.07	30.09	30.07	30.05	.04	.02
4	41	.71	.03	29.84	29.86	29.87	—.03	—.01
5	30	.67	.02	29.95	29.97	30.00	—.05	—.03
6	30	.89	.08	30.23	30.19	30.15	.08	.04
7	34	.94	.10	30.24	30.20	30.19	.05	.01
8	40	.80	.05	29.96	29.97	29.95	.01	.02
9	42	.65	.01	29.74	29.78	29.82	—.08	—.04
10	33	.96	.10	30.28	30.23	30.19	.09	.04
11	34	.99	.11	30.30	30.23	30.20	.10	.03
12	42	.97	.09	30.17	30.12	30.12	.05	.0
13	48	.81	.05	29.86	29.86	29.86	.0	.0
14	48	.70	.03	29.73	29.75	29.75	—.02	.0
15	42	.67	.02	29.77	29.82	29.81	—.04	.01
16	33	.72	.03	29.97	29.98	30.00	—.03	—.02
17	35	.97	.10	30.25	30.21	30.19	.06	.02
18	38	.82	.06	30.02	30.01	30.02	.0	—.01
19	34	.75	.04	29.99	30.01	30.06	—.07	—.05
20	33	.99	.11	30.32	30.26	30.25	.07	.01
21	39	.82	.06	30.00	30.00	29.98	.02	.02
22	45	.37	—.06	29.35	29.47	29.48	—.13	—.01
23	21	.12	—.13	29.39	29.55	29.57	—.18	—.02
24	22	.58	.0	29.96	30.00	29.90	.06	.10
25	28	24.08	.13	30.50	30.42	30.36	.14	.06
26	43	.08	.13	30.28	30.21	30.18	.10	.03
27	47	.08	.13	30.22	30.15	30.18	.04	—.03
28	47	24.09	.14	30.24	30.16	30.17	.07	—.01
29	46	24.00	.11	30.14	30.09	30.10	.04	—.01
30	46	23.97	.10	30.10	30.06	30.03	.07	.03

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An inspection of this table shows in column (8) that the errors introduced by the pressure correction are very large the greatest differences from the observed sea-level values being — .18 and + .14 and 18 of the differences being over .05. The reductions by the table in this paper are very gratifying indeed, showing all the errors less than .05 with only three exceptions. These results simply confirm those published in 1881, and show that the use of a pressure correction introduces a serious error and that we may use a simple table with only a single argument —and that for temperature—in making reductions. In addition to the lack of accuracy, the introduction of a pressure correction complicates the reduction very much and it is evident that, from all that has preceded, we must hope, for the present at least, for approximate results only, and the simpler the reduction the better.

TABLES OF REDUCTION.

There are appended to this paper, tables of reduction in accordance with the above discussion. In these tables the temperature reduction for each station has been introduced so that the only argument necessary is either, the observed temperature, so modified as to give an approximate mean for the previous 24 hours or the mean of the two previous with the observed temperature. It may be remarked that with rare exceptions either the seven hour or the twenty-three hour temperature may be used directly in the tables but not that for fifteen hours. The twenty-three hour temperature is usually very near the mean for the day and the effect of the seven hour temperature would be simply to make slightly too great a reduction.

REDUCTION TO SEA-LEVEL.

Station.	Height.	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Abilene, Texas	1744	... ..	.....	.....	.....	2 04	2.00	1.96	1.92	1.88	1.85	1.82	1.79	1.76	1.73
Albany, N. Y	83	.....	.....	.....	.....	.10	.10	.09	.09	.09	.09	.09	.08	.08	.08
Alpena, Mich	609	.....	.....	.....	.....	.74	.72	.70	.69	.68	.66	.65	.64	.63	.62
Apache, Ariz	5050	.....	.....	.....	.....	.....	.....	5.31	5.22	5.14	5.05	4.97	4.90	4.82	4.75
Assinaboine, Mont	2720	3.43	3 35	3.27	3.19	3.12	3.06	3.00	2.94	2.88	2.82	2.76	2.71	2.66	2.61
Atlanta, Ga	1129	.....	.....	.....	.....	.....	.....	1.28	1.26	1.24	1.22	1.19	1.17	1.15	1.13
Atlantic City, N. J	13	.....	.....	.....	.....	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Augusta, Ga	183	.....	.....	.....	.....	.....	.....	.21	.21	.20	.20	.19	.19	.19	.18
Baltimore, Md	45	.....	.....	.....	.....	.05	.05	.05	.05	.05	.05	.05	.05	.04	.04
Bennett, Dak	1510	1.95	1.90	1.85	1.81	1.77	1.73	1.70	1.67	1.64	1.61	1.58	1.56	1.54	1.52
Benton, Mont	2680	3.38	3.30	3.22	3.15	3.08	3.02	2.96	2.90	2.85	2.80	2.75	2.70	2.66	2.62
Bidwell, Cal	4640	.....	.....	.....	.....	.....	.....	4.87	4.79	4.71	4.64	4.57	4.51	4.45	4.39
Bismarck, Dak	1694	2.18	2.13	2.08	2.03	1.99	1.95	1.91	1.87	1.84	1.81	1.78	1 75	1.72	1.69
Block Island, R. I	27	.....	.....	...	.....	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
Boise City, Id	2750	.....	.....	.....	.....	3.15	3.09	3.03	2.97	2.92	2.87	2.82	2.77	2.72	2.67
Boston, Mass	124	.....	.....	.....	.....	.15	.14	.14	.14	.13	.13	.13	.12	.12	.12
Bridger, Wyo	6640	7.44	7.31	7.18	7.06	6.94	6.82	6.71	6.60	6.50	6.40	6.30	6.20	6.10	6.00
Brownsville, Texas	57	.....	.....	.....	.....	.....	.....	.06	.06	.06	.06	.06	.06	.06	.06
Buffalo, N. Y	690	.....	.....	.87	.85	.83	.81	.79	.77	.76	.75	.73	.72	.71	.70
Buford, Mont	1930	2.46	2.40	2.34	2.29	2.24	2 20	2.16	2.12	2.08	2.04	2.00	1.97	1.94	1.91
Burlington, Vt	268	.....	.....	.35	.34	.33	.32	.31	.31	.30	.30	.29	.28	.28	.27
Cairo, Ill	359	.....	.....	.....	.....	.....	.....	.42	.41	.40	.39	.39	.38	.37	.36
Canby, Wash	179	.....	.....	.....	.....	.....	.....	.21	.21	.20	.20	.19	.19	.19	.18
Cape Henry, Va	16	.....	.....	.....	.....	.....	.....	.02	.02	.02	.02	.02	.02	.02	.02
Cape May, N. J	27	.....	.....	.....	.....	.....	.....	.03	.03	.03	.03	.03	.03	.03	.03
Cape Mendocino, Cal	637	.....	.....	.....	.....	.....	.....	.73	.72	.71	.70	.68	.67	.66	.65
Cedar Keys, Fla	22	.....	.....	.....	.....	.....	.....	.02	.02	.02	.02	.02	.02	.02	.02
Charleston, S C	52	.....	.....	.....	.....	.....	.....	.06	.05	.05	.05	.05	.05	.05	.05
Charlotte, N. C	808	.....	.....	.....	.....	.....	.....	.93	.91	.89	.87	.85	.84	.83	.82
Chattanooga, Tenn	783	.....	.....	.....	.....	.....	.....	.89	.87	.85	.84	.83	.82	.81	.80
Cheyenne, Wyo	6105	7.03	6.90	6 78	6.66	6.54	6.42	6.30	6.18	6.07	5.96	5.85	5.74	5.63	5.52
Chicago, Ill	715	.93	.91	.89	.87	.85	.83	.81	.79	.78	.77	.76	.75	.74	.73
Chincoteague, Va	8	.....	.....	.....	.....	.....	.....	.01	.01	.01	.01	.01	.01	.01	.01
Cincinnati, O	628	.84	.82	.80	.78	76	.74	.73	.71	.70	.68	.67	.66	.65	.64
Cleveland, O	690	.91	.89	.87	.85	.83	.81	.79	.77	.76	.75	.74	.73	.72	.71
Columbus, O	812	1.05	1.03	1.01	.99	.97	.95	.93	.91	.89	.87	.85	.84	.83	.82
Concho, Texas	1900	.....	.....	....	.....	2.22	2.17	2.13	2.09	2.05	2.01	1.97	1.93	1.90	1.87
Concordia, Kan	1410	1.83	1.78	1.74	1.70	1.66	1.63	1.60	1.57	1.54	1.51	1.48	1.45	1.42	1.39
Custer, Mont	3040	3.77	3.69	3.62	3.55	3.48	3.41	3.34	3.27	3.20	3.14	3.08	3.03	2.98	2.93
Davenport, Ia	615	.82	.80	.78	.76	.74	.72	.70	.69	.68	.67	.66	.65	.64	.63
Davis, Texas	4930	.....	.....	.....	.....	5.40	5.30	5.20	5.10	5.01	4.93	4.85	4.77	4.69	4.61
Dayton, Wash	1680	.....	.....	.....	.....	1.97	1.93	1.89	1.85	1.82	1.79	1.76	1.73	1.70	1.67
Deadwood, Dak	4600	5.50	5.39	5.29	5.19	5 09	4.99	4.89	4.79	4.69	4.60	4.51	4.43	4.35	4.27
Del. Breakwater, Del	20	.....	.....	.....	.....	.....	.....	.02	.02	.02	.02	.02	.02	.02	.02
Denver, Col	5294	6.20	6.09	5.98	5 87	5.76	5.65	5.54	5.44	5.34	5 24	5.14	5.05	4.96	4.87
DesMoines, Ia	842	1.11	1.08	1.05	1.02	1.00	.98	.96	.94	.92	.90	.88	.87	.86	.85
Detroit, Mich	662	.87	.85	.83	.81	.79	.77	.75	.74	.73	.72	.71	.70	.69	.68
Dodge City, Kan	2517	3.17	3.09	3.02	2.96	2.90	2.84	2.79	2.74	2.69	2.64	2.59	2 55	2.51	2.47
Dubuque, Ia	665	.87	.85	.83	.81	.79	.77	.75	.74	.73	.72	.71	.70	.69	.68
Duluth, Minn	672	.88	.86	.84	.82	.80	.78	.76	.75	.74	.73	.72	.71	.70	.69
Eastport, Me	61	.....	.....	.....	.....	.07	.07	.07	.07	.07	.06	.06	.06	.06	.06
Edmonton, B. C	2200	2.79	2.72	2.66	2.60	2.55	2.50	2.45	2.40	2.36	2.32	2.28	2.24	2.20	2.16
Elliott, Texas	2650	.....	.....	.....	.....	3.05	2.99	2.93	2.87	2.82	2.77	2.72	2.68	2.64	2.60
El Paso, Texas	3760	.....	.....	.....	.....	.....	.....	4.06	3.99	3.92	3.85	3.79	3.73	3.67	3.61
Erie, Pa	681	.90	.88	.86	.84	.82	.80	.78	.76	.74	.73	.72	.71	.70	.69
Escanaba, Mich	608	.81	.79	.77	.75	.73	.71	.69	.68	.67	.66	.65	.64	.63	.62
Fort Smith, Ark	470	.....	.....	.....	.....	.57	.55	.54	.53	.52	.51	.50	.49	.48	.47
Frisco, Nev	6400	.. ..	.....	...	.....	.....	.....	6.51	6.41	6.31	6.21	6.11	6.01	5.92	5.83
Galveston, Texas	40	.....	.....	.....	.....	.....	.....	.04	.04	.04	.04	.04	.04	.04	.04
Gibson, Ind	540	.....	.....	.....	.....	.....	.....	.62	.61	.60	.59	.58	.57	.56	.55
Grand Haven, Mich	620	.82	.80	.78	.76	.74	.72	.70	.69	.68	.67	.66	.65	.64	.63
Grant, Ariz	4860	...	.....	.....	.....	.....	.....	5.14	5.05	4.96	4.88	4.80	4.72	4.64	4.58
Greencastle, Ind	897	1.20	1.16	1.13	1.10	1.07	1.05	1.03	1.01	.99	.97	.95	.93	.91	.89
Helena, Mont	4069	4.89	4.79	4.70	4.61	4.53	4.44	4.36	4.29	4.22	4.15	4.08	4.01	3.95	3.89
Huron, Dak	1307	1.71	1.66	1.62	1.58	1.55	1.52	1.49	1.46	1.43	1.40	1.37	1.34	1.32	1.30
Indianapolis, Ind	766	1.00	.98	.96	.94	.92	.90	.88	.86	.84	.83	.82	.81	.80	.79
Indianola, Texas	26	.....	.....	.....	.....	.....	.....	.03	.03	.03	.03	.03	.03	.03	.03
Jacksonville, Fla	43	.....	.....	.....	.....	.....	.....	.04	.04	.04	.04	.04	.04	.04	.04
Keeler, Cal	3622	.....	.....	.....	.....	.....	.....	3.93	3.85	3.78	3.71	3.65	3.59	3.53	3.47
Keokuk, Ia	618	.82	.80	.78	.76	.74	.72	.70	.69	.68	.67	.66	.65	.64	.63
Key West, Fla	20	.....	.....	.....	.....	.....	.....	.02	.02	.02	.02	.02	.02	.021	.02

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Station.	Height	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Kitty Hawk, N. C.	9	.....	.....	.....	.....	.....	.....	.01	.01	.01	.01	.01	.01	.01	.01
Knoxville, Tenn.	980	.....	.....	.....	.....	1.17	1.14	1.12	1.10	1.08	1.06	1.04	1 02	1.00	.98
La Crosse, Wis.	725	.94	.92	.90	.88	.86	.84	.82	.80	.79	.78	.77	.76	.75	.74
Lamar, Mo.	1020	1.34	1.30	1.27	1.24	1.21	1.18	1.16	1.14	1.12	1.10	1.08	1.06	1.04	1.02
Las Animas, Colo.	3900	4 71	4.61	4.52	4.44	4.36	4.28	4.20	4.13	4.06	3.99	3.92	3.86	3.80	3.74
Leavenworth Kan.	842	.....	.....	.....	.....	1.00	.98	.96	.94	.92	.90	.88	.87	.86	.85
Lewiston, Id.	780	.....	.....	.....	.....	.....	.....	.89	.87	.85	.84	.83	.82	.81	.80
Little Rock, Ark.	310	.....	.....	.....	.....	.....	.....	.36	.35	.35	.34	.33	.33	.32	.31
Los Angeles, Cal.	339	.....	.....	.....	.....	.....	.....	.39	.38	.38	.37	.36	.36	.35	.34
Louisville, Ky.	551	.....	.....	.....	.....	.....	.....	.62	.61	.60	.59	.58	.57	.56	.55
Lynchburg, Va.	652	.....	.....	.....	.....	.....	.....	.74	.72	.71	.70	.69	.68	.67	.66
Mackinaw City, Mich.	605	.81	.79	.77	.75	.73	.71	.69	.68	.67	.66	.65	.64	.63	.62
Macon, N. C.	11	.....	.....	.....	.....	.....	.....	.01	.01	.01	.01	.01	.01	.01	.01
Maginnis, Mont.	4370	5.22	5.11	5.01	4.92	4.83	4.74	4.66	4.58	4.50	4.42	4.34	4.27	4.19	4.11
Marquette, Mich.	673	.88	.86	.84	.82	.80	.78	.76	.75	.74	.73	.72	.71	.70	.69
Medicine Hat, B. C.	2140	2.72	2.65	2.59	2.53	2.48	2.43	2.38	2.34	2.30	2.26	2.22	2.18	2.14	2.10
Memphis, Tenn.	320	.....	.....	.....	.....	.....	.....	.37	.36	.36	.35	.34	.34	.33	.32
Milwaukee, Wis.	697	.92	.90	.88	.86	.84	.82	.80	.78	.77	.76	.75	.74	.73	.72
Minnedosa, Man.	1800	2.30	2.25	2.20	2.15	2.10	2.06	2.02	1.98	1.94	1.90	1.87	1.84	1.81	1.78
Mobile, Ala.	35	.....	.....	.....	.....	.....	.....	.04	.04	.04	.04	.03	.03	.03	.03
Montgomery, Ala.	219	.....	.....	.....	.....	.....	.....	.26	.25	.25	.24	.24	.23	.23	.22
Montrose, Colo.	5780	.....	.....	.....	...	6.19	6.08	5.97	5.87	5.77	5.68	5.59	5.51	5.43	5.35
Moorhead, Minn.	926	1.23	1.19	1.16	1.13	1.10	1.08	1.06	1.04	1.02	1.00	.98	.96	.94	.92
Mt. Washington, N. H.	6279	7.56	7.35	7.15	6.96	6.78	6.61	6.45	6.30	6.17	6.03	5.91	5.78	.....	.....
Nashville, Tenn.	549	.....	.....	.....	.....	.....	.....	.62	.61	.60	.59	.58	.57	.56	.55
New Haven, Conn.	107	.....	.....	.....	.....	.13	.13	.13	.13	.12	.12	.12	.12	.11	.11
New London, Conn.	47	.....	.....	.....	.....	.06	.06	.06	.05	.05	.05	.05	.05	.05	.04
New Orleans, La.	52	.....	.....	.....	.....	.....	.....	.06	.05	.05	.05	.05	.05	.05	.05
New York City, N. Y.	164	.....	.....	.....	.....	.19	.19	.19	.18	.18	.18	.17	.17	.17	.16
Norfolk, Va.	30	.....	.....	.....	.....	.....	.....	.03	.03	.03	.03	.03	.03	.03	.03
North Platte, Neb.	2841	3.53	3.45	3.38	3.31	3.24	3.18	3.12	3.06	3.00	2.95	2.90	2.85	2.80	2.75
Olympia, Wash.	36	.....	.....	.....	.....	.....	.....	.04	.04	.04	.04	.04	.04	.04	.04
Omaha, Neb.	1113	1.45	1.41	1.38	1.35	1.32	1.29	1.26	1.23	1.20	1.18	1.16	1.14	1.12	1.10
Oswego, N. Y.	335	.45	.44	.43	.42	.41	.40	.39	.38	.38	.37	.36	.36	.35	.35
Palestine, Texas	533	.....	.....	.....	.....	.....	.....	.60	.59	.58	.57	.56	.55	.54	.53
Pensacola, Fla.	30	.....	.....	.....	.....	.....	.....	.03	.03	.03	.03	.03	.03	.03	.03
Philadelphia, Pa.	117	.....	.....	.....	.....	.14	.14	14	.14	.13	.13	.13	.13	.13	.12
Pittsburg, Pa.	771	.....	.....	.....	.....	.92	.90	.88	.86	.84	.83	.82	.81	.80	.79
Poplar River, Mont.	2000	2.53	2.47	2.42	2.37	2.32	2.27	2.23	2.19	2.15	2.11	2.07	2.04	2.01	1.98
Port Angeles	14	.....	.....	.....	.....	.....	.....	.01	.01	.01	.01	.01	.01	.01	.01
Port Huron, Mich.	633	.84	.82	.80	.78	.76	.74	.73	.71	.70	.68	.67	.66	.65	.64
Portland, Me	99	.....	.....	.....	.....	.....	.....	.12	.11	.11	.11	.11	.11	.10	.10
Portland, Or.	80	.....	.....	.....	.....	.....	.....	.09	.09	.09	.09	.09	.08	.08	.08
Prescott, Ariz.	5390	.....	.....	.....	.....	.....	.....	5.67	5.57	5.47	5.38	5.30	5.22	5.14	5.06
Q'Appelle, B. C.	2115	2.69	2.62	2.56	2.51	2.46	2.41	2.36	2.31	2.27	2.23	2.19	2.15	2.12	2.09
Red Bluff, Cal.	342	.....	.....	.....	.....	.41	.40	.39	.38	.38	.37	.36	.36	.35	.35
Rio Grande City, Tex.	230	.....	.....	.....	.....	.....	.....	.27	.26	.26	.25	.25	.24	.24	.23
Rochester, N. Y.	621	.83	.81	.79	.77	.75	.73	.72	.70	.69	.67	.66	.65	.64	.63
Roseburg, Or.	523	.....	.....	.....	.....	.....	.....	.59	.58	.57	.56	.55	.54	.53	.52
Sacramento, Cal.	64	.....	.....	.....	.....	.....	.....	.07	.07	.07	.07	.07	.07	.06	.06
Saint Louis, Mo.	571	.76	.74	.72	.70	.68	.66	.64	.63	.62	.61	.60	.59	.58	.57
Saint Paul, Minn.	831	1.08	1.05	1.03	1.01	.99	.97	.95	.93	.91	.89	.88	.87	.86	.85
Saint Vincent, Minn.	804	1.04	1.02	1.00	.98	.96	.94	.92	.90	.88	.86	.85	.84	.83	.82
Salt Lake City, Utah	4348	.....	.....	.....	.....	.....	.....	4.64	4.56	4 48	4.41	4.34	4.27	4.20	4.13
San Antonio, Texas	781	.....	.....	.....	.....	.....	.....	.89	.87	.85	.84	.83	.82	.81	.80
San Diego, Cal.	67	.....	.....	.....	.....	.....	.....	.07	.07	.07	.07	.07	.07	.07	.07
Sandusky, O.	638	.85	.83	.81	.79	.77	.75	.73	.71	.70	.69	.68	.67	.66	.65
Sandy Hook, N. Y.	28	.....	.....	.....	.....	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
Sanford, Fla.	25	.....	.....	.....	.....	.....	.....	.02	.02	.02	.02	.02	.02	.02	.02
San Francisco, Cal.	60	.....	.....	.....	.....	.....	.....	.06	.06	.06	.06	.06	.06	.06	.06
San Luis Obispo, Cal.	270	.....	.....	.....	.....	.....	.....	.27	.26	.26	.25	.25	.24	.24	.23
Santa Fe, N. M.	7026	.....	.....	.....	.....	.....	.....	7.06	6.94	6.82	6.71	6.60	6.49	6.38	6.27
Savanah, Ga.	87	.....	.....	.....	.....	.....	.....	.11	.10	.10	.10	.10	.10	.09	.09
Shaw, Mont.	3550	4.32	4.23	4.15	4.07	3.99	3.92	3.85	3.78	3.71	3.65	3.59	3.53	3.47	3.41
Shreveport, La.	227	.....	.....	.....	.....	.....	.....	.27	.26	.26	.25	.25	.24	.24	.23
Sill, Ind. Ter.	1200	.....	.....	.....	.....	.....	.....	1.38	1.34	1.31	1.28	1.25	1.23	1.21	1.19
Smithville, N. C.	34	.....	.....	.....	.....	.....	.....	.03	.03	.03	.03	.03	.03	.03	.03
Spokane Falls, Wash.	1909	.....	.....	.....	.....	2.22	2.17	2.13	2.09	2.05	2.02	1.99	1.96	1.93	1.90
Springfield, Ill.	644	.....	.....	.....	.....	.77	.75	73	.71	.70	.69	.68	.67	.66	.65
Springfield, Mass.	120	.....	.....	.....	.....	.14	.14	.14	.14	.13	.13	.13	.13	.13	.12
Stanton, N. M.	6160	.....	.....	.....	.....	.....	.....	6.28	6.17	6.06	5.96	5.86	5.77	5.68	5.59
Starkville, Miss.	455	.....	.....	.....	.....	.....	.....	.53	.52	.51	.50	.49	.48	.47	.46
Stockton, Texas	3000	.....	.....	.....	.....	.....	.....	3.29	3.23	3.17	3.11	3.06	3.01	2.96	2.91

Station.	Height	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Sully, Dak.	1600	2.05	2.00	1.96	1.92	1.88	1.84	1.80	1.77	1.74	1.71	1.68	1.65	1.62	1.59
Tatoosh, Wash.	86	.....	.....	.....	.....	.....	.....	.11	.10	.10	.10	.10	.10	.09	.09
Thatcher's, Mass.	48	.....	.....	.....	.....	.....	.....	.06	.05	.05	.05	.05	.05	.05	.04
Thomas, Ariz.	2710	.....	.....	.....	.....	.....	.....	3.00	2.94	2.88	2.83	2.78	2.73	2.68	2.63
Toledo, Ohio	651	.86	.84	.82	.80	.78	.76	.74	.72	.71	.70	.69	.68	.67	.66
Totten, Dak.	1500	1.94	1.89	1.85	1.81	1.77	1.73	1.69	1.66	1.63	1.60	1.57	1.54	1.51	1.48
Valentine, Neb.	2603	3.24	3.17	3.11	3.05	2.99	2.93	2.87	2.82	2.77	2.72	2.67	2.63	2.59	2.55
Vicksburg, Miss.	222	.....	.....	.....	.....	.....	.....	.26	.25	.25	.24	.24	.23	.23	.22
Visalia, Cal.	348	.....	.....	.....	.....	.....	.....	.40	.39	.39	.38	.37	.37	.36	.36
Walla Walla, Or.	1020	.....	.....	.....	.....	.....	.....	1.17	1.14	1.12	1.10	1.08	1.06	1.04	1.02
Washington, D C.	106	.....	.....	.....	.....	.13	.13	.13	.13	.12	.12	.12	.12	.11	.11
Williamsport, Pa.	561	.....	.....	.....	.....	.67	.65	.63	.62	.61	.60	.59	.58	.57	.56
Wilmington, N. C.	52	.....	.....	.....	.....	.06	.06	.06	.05	.05	.05	.05	.05	.05	.05
Winnemucca, Nev.	4360	.....	.....	.....	.....	4.78	4.70	4.62	4.54	4.46	4.39	4.32	4.26	4.20	4.14
Winnipeg, Man.	754	.98	.96	.94	.92	.90	.88	.86	.84	.82	.80	.78	.77	.76	.75
Woods Hall, Mass.	35	.....	.....	.....	.....	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Yankton, Dak.	1228	1.59	1.55	1.52	1.49	1.46	1.43	1.40	1.37	1.34	1.32	1.30	1.28	1.26	1.24
Yuma, Cal.	141	.....	.....	.....	.....	.....	.....	.16	.16	.16	.15	.15	.15	.15	.14

In drawing isobars careful attention must be paid to the following considerations:

1st. Uncertainty in the temperature.

2nd. Uncertainty in the height of the station.

3rd. Uncertainty in the barometer reading.

4th. Uncertainty in the law of reduction.

The first of these has already been fully dwelt upon. At stations not having a spirit level determination of height, the 2nd and 3rd considerations are mingled together in the barometric height. The variation in the barometer is unfortunately not constant but there is a gradual deterioration much greater at some stations than at others. It is believed that with an understanding of all the difficulties involved there will be no trouble experienced in giving doubtful stations less weight and in drawing isobars which shall represent fairly well changes that are going on in the pressure from day to day and from month to month.

WARM AND COLD MONTHS.

One of the more interesting results of study has been the discovery of certain months in different years when the usual rule does not apply to the reductions at high stations in the region about Deadwood, Custer, North Platte, Dodge City, Denver, and Cheyenne. There was found a peculiar law governing these abnormal cases which may be stated as follows: When the temperature is much below the mean in the Missouri Valley then the

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temperature at high stations is very much too high, even much higher than in the valley, 3,000 feet lower, and is undoubtedly strongly affected by that of the plateau regions of the west. This effect frequently extends to the height of Pike's Peak, 14,134 feet above sea. On the other hand, with a temperature above the mean, in the above valley, the higher stations show very fairly the usual law of decrease of temperature with height. January and February of the following years have been found to show the above peculiarities. Temperature, Missouri Valley below the mean, Feb. '79, Jan. and Feb. '81, Jan. '83, Jan. '84, Jan. and Feb. '85, and Jan. '86. Temperature above the mean, Feb. '78, Jan. and Feb. '80, Feb. '82 and Feb. '86. The projection of isobars for the last five months is entirely satisfactory, but for the other eight the reductions at several high stations are too small owing to their abnormally high temperature. The reduction in the latter cases will be satisfactory if we take the temperature of the lower station for that at the upper. In practice it is only necessary to give the higher stations less weight in drawing the isobars.

There are added to this paper monthly charts showing fifteen years' normal pressure, temperature and wind directions for the United States and Canada, for January and July. These charts have been constructed with great care, and may be regarded of permanent value. The only change that additional years of observations can make will be in the line of secular variation and not accidental. The original of this paper was prepared in November, 1885, but it has not been possible to publish it before the present time.

H. ALLEN HAZEN.

WASHINGTON, D. C., March 19, 1887.

SELECTION.

POPULAR ERRORS IN METEOROLOGY.

[CONTINUED.]

The case of the Rocky Mountain Locust is an instance well calculated to illustrate this latter principle, *i. e.*, that natural causes sometimes direct every step. This "pest," after its last

moulting, finds itself feeding in or near its native fields on the tender vegetation near the ground. Every day as the sun rises, after the dew is dissipated, it finds the atmosphere about it growing hot and dry, and soon also its own moist tender wings become stiffened. There results on its part a nervous irritability which can be gratified best by active flapping of its wings, so that without any other profound instinct or intention on its part, it is carried upward above the ground to cooler, moister air, where strong northwest winds carry it rapidly southward, even to the Gulf of Mexico. Therefore, its migration into a region where rich pasture-lands await it, is not due to any superior knowledge on its own part. The eggs hatch out in these southern regions at a season of the year when strong southerly winds are more frequent, and thus the young locusts are by these carried back toward their starting place, without the intervention of instinct or inherited knowledge, but by causes beyond their control.

What is true of the animals is still more plainly true of vegetables, so that in fact nearly all the rules for weather prediction founded on the behavior of plants, such as the contracting of the down of the dandelion, the closing of the pink-eyed pimpernel, or of the convolvulus, in the day-time, or the gathering of dew on stones, or the falling of soot in the chimney, are all simply so many hygroscopic phenomena, and a well-made hygrometer, as used by meteorologists, will give more accurate indications than any of these natural objects.

Another erroneous idea, very widely prevalent, is shown by the tendency to explain this or that phenomenon as being due to atmospheric electricity or possibly to ozone. Both of these subjects have thus far eluded the attempt to observe them satisfactorily; we have, indeed, so-called records of electricity and ozone, but it is safe to say that with very few, if any exceptions, we have thus far been unable to interpret these records, and demonstrate that we have been really observing a purely atmospheric phenomenon; hence, I rate as a popular error the frequent quotation of these as an exact cause of meteorological phenomena.

XUM

We have many of us been accustomed to speak of the delightful influence of a summer thunder-storm in clearing and cooling the air, and it is true that cool clear air does frequently follow these storms. We are, however, here in danger of confusing cause and effect. A certain class of thunder-storms is not generally followed by cooler air; that is to say, any cooler than it would have been without the storm, while another large class is followed by a decided fall in temperature. In these latter cases, if I am not mistaken, the underflow of cooler air contributes so largely to the existence of the storm that at first sight one would say that the refreshing cooling of the air is the cause and not the effect. But a truer philosophy would show that uprising warm moist air has caused both the inrush of cool air and the thunder-storm, so that the two latter do not stand to each other at all in the relation of cause and effect.

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[TO BE CONTINUED.]

XUM

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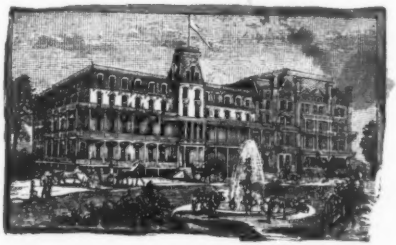

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